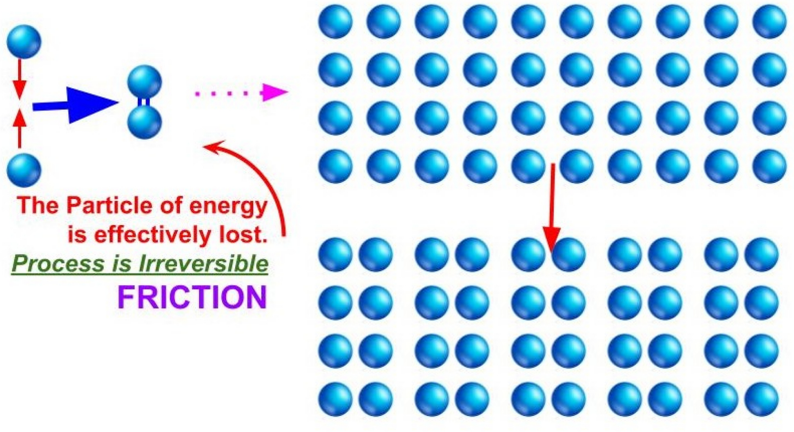
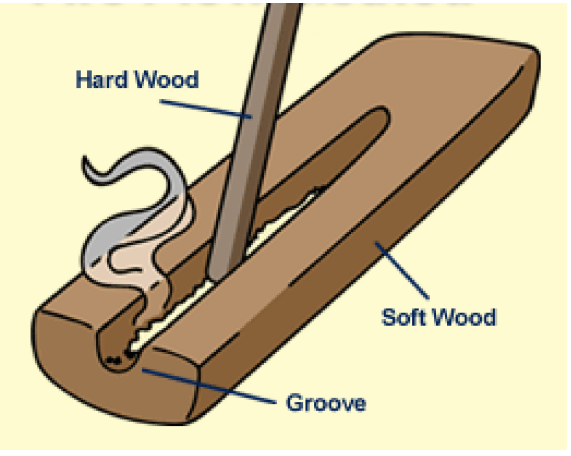
Friction and the direction of time



When a bond is formed between two atoms a quantity of energy is released as a single particle. The same particle of energy can break the bond between the two atoms. In the first case the two atoms are moving closer and after the bond has formed, the particle of energy is going away from them. {Picture left} If the direction of all these objects is reversed, the particle of energy is coming towards the bonded atoms and after the bond is broken the atoms move apart. Reversing the direction of time has caused no problem. There is a symmetry for the direction of time. Now consider the snooker game example. The first ball moving east strikes the second and stops. The second begins to move. If the direction of time is reversed, the second ball moving west hits the stationary first ball which starts to move. But if the forces of friction are included the balls are slowing because of friction. When the direction of time is reversed, the speed of the balls seem to increase without any force to cause it. This contradicts the laws of physics. Loss of energy through friction is one cause for the direction of time; to explain why everything seems to go from the past to the future but not from the future to the past. This is only for experimental physics. We cannot say that friction forces are responsible for the human experience where once again time always moves from the past to the future. One important point. The mathematical rules of physics in quantum mechanics which

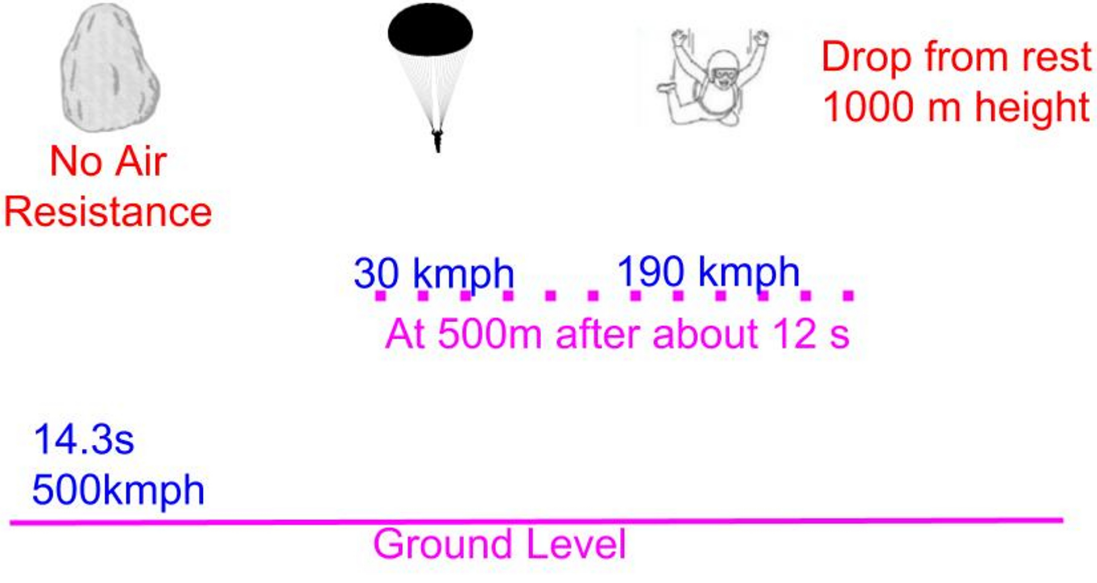
explains atomic physics and in the theory of gravity are symmetric in time. So an obvious question is why there is a direction of time in frictional forces. Do they violate the laws of physics?

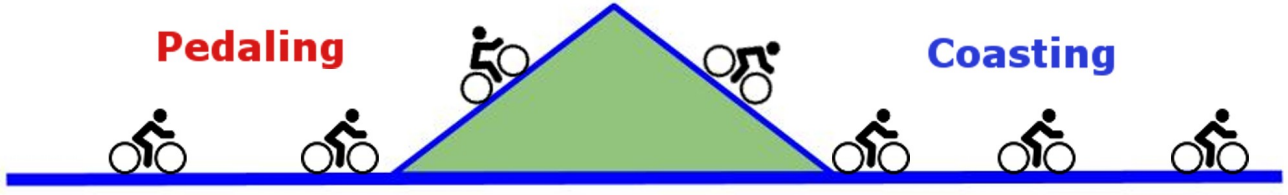
Let us consider that a bond has formed between two atoms and the particle of energy released has converted to the vibration of a number of atoms because the atoms are on a solid surface. {Picture previous page} When the direction of time is reversed, the particle of energy from the vibrating atoms should reach the specific place where the bond has formed. But this is unlikely. That particle may be located at any of the large number of vibrating atoms. So the direction of time cannot be reversed. It will always lead to bond formation. When friction cannot be neglected, the energy is lost as the vibration of a large number of atoms and so is no longer available for use. The simple assumption that energy exists as particles helps us to understand why the direction of time in real life goes only from the past to the future.



As mentioned before, the tidal movement of water leads to friction, loss of energy and slowing of the earth's rotation by 0.0002seconds every year. Our ability to produce fire as and when necessary is an important step in the development of all human culture. The movement of a hard wood in the slot made in soft wood, produces heat which makes the softwood burn. {Picture right} Sometimes friction with gases is also important. For example,

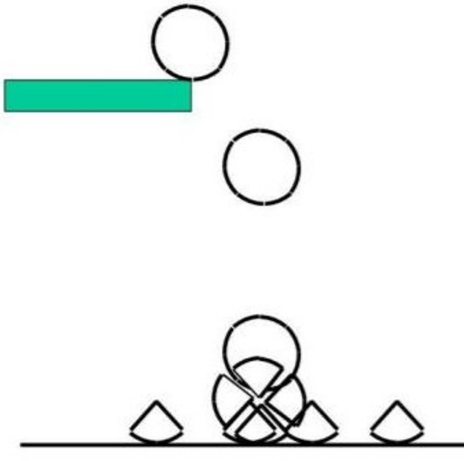
if a body is dropped from a height of 1 km, it should reach the ground in 14.3 s with a speed of more than 500 km per hour. {Picture below} But a skydiver will reach only a height of 500m after 12 s and will still be at a speed less than 190 km per hour. When the skydiver opens his parachute, the speed will reduce much further. If the parachute is used at a height of 1 km itself, the speed will not increase beyond 30 km per hour. The reason is that friction with air slows a skydiver and slows the parachute even more. Archimedes' principle tells that a heavier body will sink. It cannot tell how fast it will do so. We can assume that there is no friction, simplify the problem, and calculate how fast the body takes to fall, we



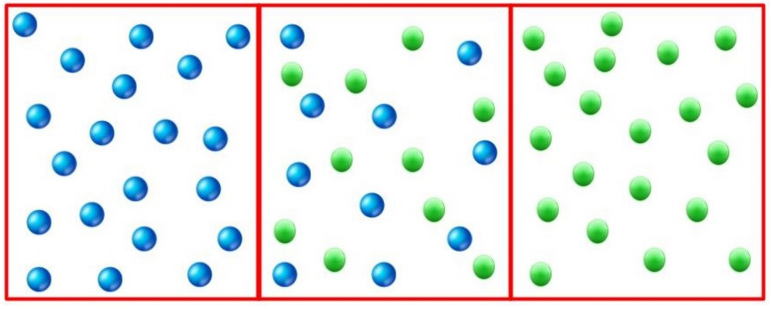


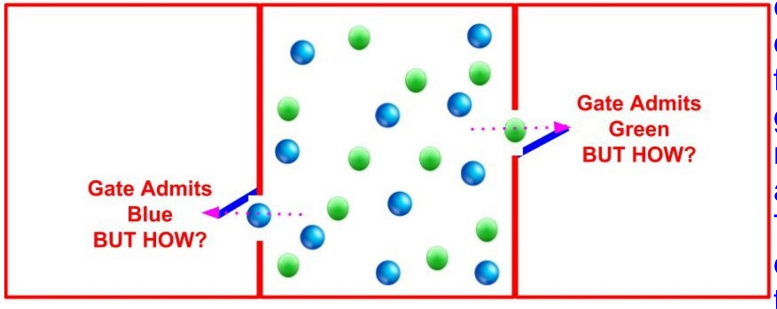
cannot calculate the changes due to friction so easily. When a cyclist goes up the hill and coasts down, we can understand that the potential energy is converted into kinetic energy. {Picture above} We cannot calculate how far the cycle will roll after reaching the ground again. That distance will depend on the friction between the ground and the cycle.

Like friction, increasing disorder is also an indicator of the direction of time from past to the future. A glass plate falling down and getting broken is natural, {Picture right} a time reversal showing pieces of glass joining to form a plate is impossible except in stories. In the picture on the next page, two gases shown with green and blue balls are initially in the two side chambers. Their mixing in the central chamber when there is an opening in the walls is natural. The mixed gas in the central chamber getting separated into the two gases in the two side chambers is odd and impossible.



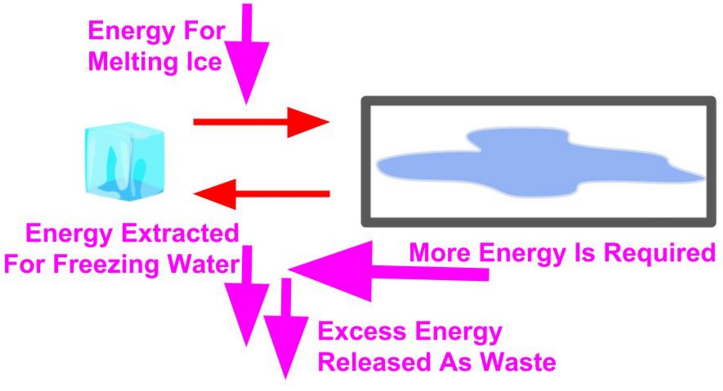
Scientists came up with a great imaginary experiment. The particles are moving anyhow due to thermal energy.





There are two imaginary gates on either side. {Picture left below} One permits gas shown with blue balls to pass through to one side chamber. The other gate allows gas shown as green balls to pass through to the other side chamber. Eventually the gases should separate without any energy being spent. This is called Maxwell's demon. How this logic contradicts physics and why such a demon will not exist is not clear at first. The limitation is in operating the gates. The should identify the gas molecule coming towards the gate and open it as and when required. This requires energy. It requires a bit of thought to confirm that disorder in the gas can only be decreased after supplying energy. A simpler idea is to watch the growth of a crystal of sugar. The crystal has less disorder but the disorder of the liquid left behind increases even more.

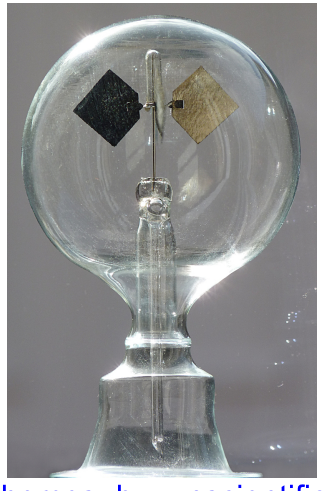
Disorder will always increase and indicates the direction of time. This principle is called the second law of thermodynamics. The first law is the law of conservation of energy. As an example of the second law of thermodynamics consider a refrigerator. A quantity of heat



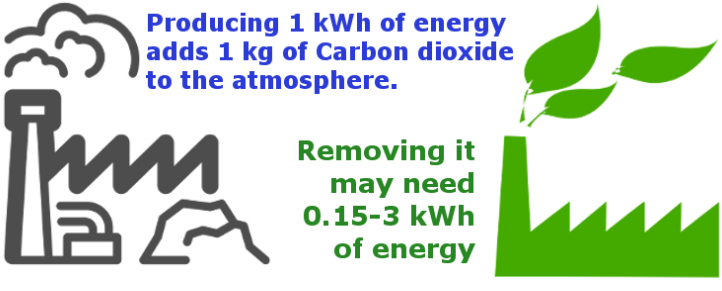
energy is required to melt one kg of ice. The same quantity of heat is to be extracted from the water to form ice again. This is the basic principle of the reversal of time. But even in an ideal refrigerator, in order to actually freeze the water and decrease the disorder, an additional quantity of heat has to be released into the atmosphere. The disorder inside the refrigerator has decreased since ice is less disordered than water. But the increase in the disorder of the surroundings is more than the decrease of disorder inside the refrigerator. Losses in a practical refrigerating machine due to friction and other causes is an additional loss. The second law of thermodynamics also demands that any engine, even an ideal one cannot convert all the energy available in the fuel into mechanical work. There has to be a loss and the loss depends on the temperature at which the engine or the refrigerator works.

Maxwell's demon appears to violate the second law of thermodynamics. It requires a careful examination to understand why this thought experiment is impossible. A similar

example in real life is the Crookes radiometer. {Picture right} The small windmill in the glass bulb seems to rotate endlessly without any source of energy. How does it move? Though the glass bulb is evacuated, there are some gas molecules left. One of the surfaces of the vanes of the windmill is coloured black while the opposite side is silvered. There is a small difference in temperature of the two surfaces. The collision of the gas molecules remaining in the bulb, with the two surfaces will not be identical. That small force is sufficient to keep the windmill moving.



Sometimes, even people with some scientific background will fall into this trap and support ideas that violate the second law. Emotionally committed to the governments and people taking action to reverse pollution and global warming they support schemes by unscientific individuals to convert plastic into fuels. But the energy content of methane is more than that of plastic. Just as a refrigerator needs additional energy to decrease disorder in water, any method of converting plastic into fuel needs extra energy. Similarly, significant amount of energy is required to convert water vapor in the air into drinking water or to remove carbon dioxide from the air and that means more carbon dioxide in the atmosphere.



Countless people make loud claims about their revolutionary machines which would extract endless energy from nowhere or machines that keep running without energy. They complain that scientists and science administrators are not cooperating in using them or in providing funds for further research. They do not recognize the strength of the laws of conservation of energy and the second law of thermodynamics.